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U.S DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER
10191/2329

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

U.S. APPLICATION NO (If known, see 37 CFR 1.5)
10/089620

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE(S) CLAIMED
PCT/DE00/02546	(02.08.00) 02 August 2000	(30.09.99) 30 September 1999

TITLE OF INVENTION
DEVICE AND METHOD OF CONTROLLING A DRIVE UNIT

APPLICANT(S) FOR DO/EO/US

JAUTELAT, Ruediger; SOMMER, Rainer; and EGE, Taskin

Applicant(s) herewith submit to the United States Designated/Elected Office (DO/EO/US) the following items and other information

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) immediately rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made, however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U S.C. 371(c)(4)) (unsigned).
10. ☒ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3 31 is included.
13. ☒ A **FIRST** preliminary amendment
    ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
14. ☒ A substitute specification and a marked up version thereof.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information: International Search Report (translated), International Preliminary Examination Report (translated) and Form PCT/RO/101.

Express Mail No. EJ003626037US

U.S. APPLICATION NO if known, see 37 C.F.R.1.5	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
10/089620	PCT/DE00/02546	10191/2329

17. ☒ The following fees are submitted.	CALCULATIONS	PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)): Search Report has been prepared by the EPO or JPO $890.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) . . $710.00		
No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) $740 00		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO $1,040.00		
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) $100.00		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 890	
Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

Claims	Number Filed	Number Extra	Rate		
Total Claims	8 - 20 =	0	X $18.00	$ 0	
Independent Claims	3 - 3 =	0	X $84.00	$ 0	
Multiple dependent claim(s) (if applicable)			+ $280.00	$ 0	
TOTAL OF ABOVE CALCULATIONS =				$ 890	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1 27, 1.28).				$	
SUBTOTAL =				$ 890	
Processing fee of $130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$ 890	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 per property +				$	
TOTAL FEES ENCLOSED =				$ 890	
				Amount to be refunded	$
				charged	$

a. ☐ A check in the amount of $_____ to cover the above fees is enclosed.

b. ☒ Please charge my Deposit Account No. 11-0600 in the amount of $890.00 to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 11-0600. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1 137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO

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458522

[10191/2329]

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s)	:	Ruediger JAUTELAT et al.
Serial No.	:	To Be Assigned
Filed	:	Herewith
For	:	DEVICE AND METHOD OF CONTROLLING A DRIVE UNIT
Art Unit	:	To Be Assigned
Examiner	:	To Be Assigned

Assistant Commissioner for Patents
Washington, D.C. 20231

PRELIMINARY AMENDMENT AND
37 C.F.R. § 1.125 SUBSTITUTE SPECIFICATION STATEMENT

SIR:

Please amend without prejudice the above-identified application before examination, as set forth below.

IN THE SPECIFICATION AND ABSTRACT:

In accordance with 37 C.F.R. § 1.121(b)(3), a Substitute Specification (including the Abstract, but without claims) accompanies this response. It is respectfully requested that the Substitute Specification (including Abstract) be entered to replace the Specification of record.

IN THE CLAIMS:

On the first page of the claims, first line, change "What is claimed is:" to --WHAT IS CLAIMED IS:--.

Without prejudice, please cancel original claims 1 to 8 and please add new claims 9 to 16 as follows:

--9. (New) A device for controlling a drive unit, the drive unit being of an internal combustion engine in a vehicle, the device comprising:

at least one sensor;

at least one actuator;

a controller; and

at least two processors;

wherein at least one program memory contains program code and is assigned to each of the at least two processors, and the program code in the at least two program memories is identical.

10. (New) The device of claim 9, wherein the at least one sensor is connected to a first processor, and the at least one actuator is connected to one of the first processor and at least one second processor, the processors also being connected.

11. (New) The device of claim 9, wherein there are at least two sensors and at least two actuators, and each sensor and each actuator is assigned to one of the at least two processors and the at least one program memory assigned to it.

12. (New) A control unit for controlling a drive unit, the drive unit being of an internal combustion engine in a vehicle, the control unit comprising:

at least two processors; and

at least one program memory containing program code assigned to each of the at least two processors, the program code being identical in the at least two program memories.

13. (New) A method for controlling a drive unit, the drive unit being of an internal combustion engine in a vehicle, the method comprising:

determining at least one performance quantity of the drive unit;

controlling, as a function of the at least one performance quantity, at least one actuator of the drive according to at least one of predefinable and selectable functionalities using controlled variables;

processing, in at least one controller by at least two processors, the possible functionalities, wherein the functionalities are predefined by program code in at least one program memory assigned to each of the at least two processors, and the functionalities per processor and the program codes are identical in the program memories assigned to the at least two processors.

14. (New) The method of claim 13, wherein the at least one performance quantity is processed in a first processor, and the at least one actuator is controlled with at least one controlled variable from one of the first processor and at least one second processor, the processors exchanging information.

15. (New) The method of claim 13, wherein a distinction is made between performance quantities of a first type and of a second type, the performance quantities of the first type being processed in the functionalities of the at least two processors, and the performance quantities of the second type being processed only in the functionalities of one of the at least two processors.

16. (New) The method of claim 15, wherein a distinction is made between controlled variables of the first type and controlled variables of the second type, the controlled variables of the first type being formed by the functionalities of a first processor from the performance quantities which are processed in the functionalities of a first processor, and the controlled variables of the second type being formed by the functionalities of the first processor from the performance quantities which are processed in the functionalities of a second processor, and the functionalities of the at least two processors exchange information.--.

Remarks

This Preliminary Amendment cancels without prejudice original claims 1 to 8 in the underlying PCT Application No. PCT/DE00/02546, and adds without prejudice new claims 9 to 16. The new claims conform the claims to U.S. Patent and Trademark Office rules and do not add new matter to the application.

In accordance with 37 C.F.R. § 1.121(b)(3), the Substitute Specification (including the Abstract, but without the claims) contains no new matter. The amendments reflected in the Substitute Specification (including Abstract) are to conform the Specification and Abstract to U.S. Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. § 1.121(b)(3)(iii) and § 1.125(b)(2), a Marked Up Version Of The Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. In the Marked Up Version, underlining indicates added text and bracketing indicated deleted text. Approval and entry of the Substitute Specification (including Abstract) is respectfully requested.

The underlying PCT Application No. PCT/DE00/02546 includes an International Search Report, dated November 29, 2000. The Search Report includes a list of documents that were uncovered in the underlying PCT Application. A copy of the Search Report accompanies this Preliminary Amendment.

The underlying PCT application also includes an International Preliminary Examination Report, dated November 14, 2001. An English translation of the International Preliminary Examination Report accompanies this Preliminary Amendment.

Applicants assert that the subject matter of the present application is new, non-obvious, and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully Submitted,
KENYON & KENYON

Dated: 4/1/2002

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DEVICE AND METHOD OF CONTROLLING A DRIVE UNIT

Background Information

The present invention relates to a device and a method of controlling a drive unit, in particular an internal combustion engine in a vehicle.

German Patent Application 42 31 449 A1 describes a device for controlling the drive power of an engine having at least two control units, a first control unit being connected to a first group of measuring devices and a second control unit being connected to a second group of measuring devices of the same measuring element. There are special advantages of an engine which has two independent cylinder blocks and is controlled by two control units or controllers. Due to the fact that multiple control units are connected to only one measuring element for detection of the performance quantity, a high availability and operating reliability are guaranteed. The system presented here having two control units has an asymmetrical functionality and program code and originally has a main computer, which is heavily utilized, and an emergency computer, which is only lightly utilized. Individual functions of the main computer are shifted to the emergency computer to optimize computation time and memory.

Instead of two controllers, German Patent Application 35 39 407 A1 describes a computer system having two processors for regulating characteristic quantities of an internal combustion engine. The two processors share the computer load in normal operation, each of the two processors being able to maintain emergency operation as an emergency computer in the

event of malfunction. Thus, only the functions needed in emergency operation are implemented on both processors. However, in emergency operation these functions have a reduced extent of performance and function in comparison with normal operation. Due to this increased redundancy and division of work in normal computer operation, which is possible as part of the emergency function, reliability and operating speed may be increased.

Due to the asymmetrical division of functions of each controller or processor, the respective functionality must be defined, implemented, documented, tested, and maintained separately. Likewise, both controllers or computers must be equipped in the development stage with expensive measuring means and/or emulation means. Due to the asymmetrical definition of the functionality and therefore the asymmetrical definition of the systems, additional errors may occur due to a mix-up during assembly of the components, for example. At the same time, a further development of or change in functionality in the existing system requires that both controllers or computers and their respective functionalities be taken into account, which consequently is very complicated, time consuming and cost intensive.

This results in the object of implementing an engine control system having a very high functionality which is optimized with respect to the related art.

This is achieved through the characterizing features of the independent claims.

Advantages of the Invention

A control system of a drive unit, in particular of an internal combustion engine having a control unit where the control unit contains at least two computers, is described. The functionality of the control unit or controller, too complex

for one computer, is divided among at least two computers in one controller. The program memories of the two computers or computing units contain the same program code, so that both computers have an identical possible functionality. Thus the individual functionalities are advantageously selectable to be less complex than the required overall functionality, so that the complex overall functionality is nevertheless obtained via all computers or processors. In use, largely the same program code is run through, although there may be individual parts that are present in both memories or computers but are processed asymmetrically, i.e., only in or from one memory.

The functions may advantageously be divided among more than two computers, or additional computers may be present in the overall system, although they execute a different program code, i.e., they have a different functionality. The computers may then be appropriately accommodated in different controllers.

The two computers having identical possible functionalities may appropriately exchange information, e.g., over a serial or parallel bus system such as a CAN bus or other serial interfaces or a DPRAM. It is also advantageous that the functionality need only be defined, implemented, documented, tested and maintained once due to the symmetrical division of function and the identical functionalities, but it may be used for both computers or computer units.

In manufacturing the controller, e.g., in prototype building or in production, the program memory which contains the program code and thus the functionality is advantageously assembled twice in the controller, so there is no possibility of mix-ups.

In the development and application phase, one may appropriately concentrate on one of the symmetrical sides. It is sufficient to equip one side with expensive measuring means

or emulation devices. Due to the symmetrical division of functions and the symmetrical functionality on both computers, a modular design of the controller and the controller program is possible. This makes further developments through changes in existing functions and/or introduction of new functions much easier and faster in comparison with an asymmetrical structure because there are no interface problems or timing problems between the functions distributed among the computers. This results in lower development costs and shorter development times.

The main point is thus the symmetry and functionality of the computer system and the use of program memories having a completely identical program code for the at least two computers or computing units in the controller.

Additional advantageous embodiments are characterized in the description and claims.

Drawing

The present invention is explained in greater detail below on the basis of the embodiments illustrated in the drawing. Figure 1 shows a block diagram of a control unit having two computing elements or computers which control at least one performance quantity in the vehicle, preferably the performance of a drive unit, in particular of an internal combustion engine.

Figure 2 illustrates functional relationships between the two computers in the controller and their environment.

Figure 3 shows the concrete embodiment in functional relationships based on lambda regulation for calculation of injection in the internal combustion engine.

Description of the Exemplary Embodiments

Figure 1 shows an electronic controller 100, which includes at least two computers 101 and 102, an input module 103, an output module 104 and a bus system 105. Other components and/or modules may optionally be connected to bus system 105 as indicated by element 106. These additional optional elements include, for example, additional memory elements and/or an additional bus input/output interface, e.g., for diagnosis or for connection of controller 100 to other controllers. Input module 103 may be combined with output module 104 as well as the input/output module. Computer 101 contains, among other things, a processor 109 and a program memory 107 assigned to this processor 109. The program code filed in program memory 107 corresponds to the possible functionality with regard to the control or regulation of at least one performance quantity such as that which is processable by processor 109. It is advantageous for the reasons given above if first computer 101 and second computer 102 have a completely identical design, likewise with a processor 110 and a program memory 108 allocated to them. However, different computers may optionally also be used as long as the possible functionality of both computing units is identical. Input module 103 receives signals which represent measured performance quantities of the drive unit, the drive train and/or the vehicle or from which such performance quantities may be derived. In particular, these are performance quantities which may be analyzed to control an internal combustion engine. These signals are picked up by measuring devices 111 through 113, in particular sensors, and are sent to input module 103 via input lines 114 through 116.

Furthermore, signals which actuate control elements or actuators for setting at least one performance quantity of the drive unit, in particular the internal combustion engine of the vehicle, are also output via output module 104. The corresponding signals for controlling actuators 117 through

119 are delivered via output lines 120 through 122. Depending on the input signals, performance quantities and/or internal quantities derived from them, computers 101 and 102 form values for the controlled variables which are to be output and which set the control elements in the sense of a predetermined control or regulatory strategy as part of the programs implemented therein. Controller 100 is preferably a control unit for controlling a drive unit, in particular of an internal combustion engine, of a vehicle, so the position of an operating element that may be operated by the driver is detected and analyzed in a known way and a setpoint value for a torque of the drive unit is determined. A setpoint value for the torque is then determined by taking into account setpoint values of other control systems received over input module 103, e.g., a traction control, a transmission control, etc., as well as setpoint values formed internally (limits, etc.). Then in a preferred embodiment of an internal combustion engine control system, this is converted to a setpoint value for setting the throttle valve, which is set as part of a position control loop. Furthermore, depending on the design of the internal combustion engine, additional performance-determining functions are provided, e.g., a control for a turbo charger of an exhaust gas recycling system, an idling speed regulation, etc.

In addition, with internal combustion engines having direct gasoline injection, not only the air setting but also the determination of the fuel mass to be injected, the determination of an air/fuel ratio to be set, the preselection of the injection course (pre-injection, post-injection), the control of a charge movement valve, etc., have a crucial effect on performance, so that, in addition to the programs described there, a plurality of other programs are to be provided which have an influence on the performance of the internal combustion engine and thus on the safety of the vehicle.

This plurality of programs is filed or may be installed in the form of a program code in respective program memories 107 and 108 of the computer. The functionalities of a controller represented by the programs or program code in the program memory as described here are generally very complex. Therefore, these complex functionalities of the controller should be divided symmetrically between at least two computers in such a controller. The computers may exchange information, e.g., over a communication system, in particular a bus system such as a CAN bus or another serial or parallel interface or a memory element, in particular a DPRAM. Program memories 107 and 108 of two computers 101 and 102 contain the same program code. In addition, the identical program code is also executed to a great extent, but there may be individual parts which, for some reason, are processed asymmetrically. For example, the required programs or sections to be processed asymmetrically may then be activated or deactivated via hardware lines and signals transmitted on them. For the sake of simplicity of the diagram, these line connections are represented by communication system 105 and/or are integrated into it.

The procedure described above is illustrated in Figure 2 with regard to a division of functions F1 through F4 as an example. The controller is again labeled as 100, and the two computers are labeled as 101 and 102. An internal combustion engine having the respective actuators and sensors is labeled as 200. This specific example shows an internal combustion engine having 12 cylinders divided into two cylinder blocks of six cylinders each. The 12 cylinders are shown only as an example, and it is equally possible for a different number of cylinders to be provided in respective cylinder blocks 200a and 200b, each having the respective sensors and other actuators. Thus, in a 12-cylinder engine, for example, six cylinders are operated by each computer with regard to ignition and injection in a gasoline engine. The functionality is distributed symmetrically among the two computers.

Functionality F1 controls one cylinder block with the respective sensors and actuators of the internal combustion engine. Sensor quantities such as the air/fuel ratio, the camshaft or crankshaft position, knocking information, air mass, etc. from internal combustion engine 200 are sent to computers 101 and 102, in particular their functionality F1 (205, 206). Actuating signals (204, 207) from functionality F1 reach the internal combustion engine or its actuators. Oriented connections 204 through 207 represent the functionality of the transmission per se.

There is also the possibility of utilizing circuit parts or sensors via both processors. For example, the sensor, e.g., a hot film air mass flow sensor and an input circuit, e.g., a low-pass filter, may be present only once for cost reasons, but the sensor signal, e.g., an A/D-converted air flow, is available to the functionalities in both computers.

Likewise, a controller, e.g., a secondary air pump having the corresponding output stage in the controller may be operated by only one computer, whereas the respective engine function, e.g., the secondary air control including diagnosis, runs symmetrically in both computers and also supplies quantities for other engine functions.

In addition, actuators such as secondary air valve for a first cylinder block may be operated by the computer for the other cylinder block, namely the second, although the respective engine function is running in the computer for the first cylinder block.

Another possibility is for the program code for operation of the actuator, e.g., for regulating the position of the throttle valve, to run symmetrically in both computers, in which case, however, the output stage and the actuator are operated on one cylinder block, but on the other cylinder block the signal from the computer is not used for control

purposes.

Due to the embodiments described above as well as the following description of the tank system, it is obvious that despite the identity of the functionalities and the program code, certain asymmetries are possible.

Additional peripherals such as a tank system 201 are controlled and monitored by another functionality F2. This functionality F2 is likewise contained symmetrically in both computers 101 and 102. However, it is processed only asymmetrically by computer 101, for example. Therefore, this functionality F2 is activated or deactivated by signals of separate hardware lines or by unambiguous signals or data over the communication system. Thus, if there is only one tank in the vehicle, diagnosis of the tank is performed in only one computer. Although corresponding functionality F2 is present on both computers in the program memory, it is activated on only one side. The communication relationship between functionality F2 in computer 101 and tank system 201 is represented by connections 202 and 203.

In addition, functionalities F3 and F4 may also be provided for other peripheral elements, so that, on one hand, sensor elements 209 and 210 may be input and processed via communication link 213 and 214 (F3). On the other hand, control elements, actuators 208 and 211 may also be operated via communication links 212 and 215 by functionalities F4. Likewise, quantities to or from other control systems such as a traction control, a transmission control, etc. may be relayed via oriented connections 212 through 215. If sensor element 209 and control element 208 are elements of the same control loop, functionalities F3 and F4 may also be considered together as functionality F34.

Figure 3 shows a very special embodiment of a 12-cylinder engine having a concrete functionality. Thus, this 12-cylinder

engine has four parallel exhaust gas lines, for example, having four regulating probes 310 through 313, combined as lambda probes 300. Thus a quadro lambda regulation would have to be provided in the engine control unit, but because of its high complexity this entails not only increased costs but also risks with regard to malfunctions, in particular security risks. Due to the symmetrical division of functions between two computers, there is only one stereo-lambda regulation in each computer 101 or 102 in controller 100, i.e., the functionality is far less complex. The signals supplied by probes 310 through 313 go via interfaces 314 through 317 for hardware processing. This signal processing takes place through elements 308 and 309 for computer 101 and through elements 306 and 307 for computer 102. Probe signals US1 and US2 are thus sent to computer 102, and probe signals US3 and US4 are sent to computer 101.

Thus only two probe signals are analyzed in each computer, and the lambda regulation factors act, as explained later, only on six injectors via the injection calculation. Then, as stated previously, the same-stereo lambda regulation is performed in block 304a and 304b. To do so, processed probe signals US1 and US2 enter the regulation as probe signals USX and USY. Likewise, processed probe signals US3 and US4 in block 304b also enter as USX and USY into the same stereo-lambda regulation. Regulating factors FRX and FRY that are obtained from the stereo-lambda regulation are relayed to downstream blocks 305a and 305b for computer 102 and computer 101, respectively.

Based on regulation factors FRX and FRY, the same injection calculation is then performed in blocks 305a and 305b for six injectors in this embodiment. The resulting output quantity groups 318 and 319 are then relayed to output stage blocks 320 and 321.

On the basis of the same program code or the identical

functionalities, the function blocks are also identical. Likewise, input quantities, output quantities and state variables of computers 101 and 102 have identical designations. Output quantities 318 and 319 are equally designated as ti1 through ti6, although they have physically different meanings. Thus, ti1 is used once for controlling injector 1, EV1, and once for controlling injector 7, EV7. However, this has no relevance for the function or functionality or the program code. Injectors 301 are then controlled via interface 302 or 303 from output stage blocks 320 and 321.

The symmetrical distribution of functions discussed above is illustrated in Figures 1, 2 and 3, although parts may be processed asymmetrically. Nevertheless, the functionality and the program code are identical for both computers and are run through in both computers independently of one another. There is no redundancy and there are no emergency operating properties in sensors, output stages or functionality. Such a redundancy would have to be generated additionally, independently of the concept according to the present invention.

What is claimed is:

1. A device for controlling a drive unit, in particular of an internal combustion engine in a vehicle, having at least one sensor and at least one actuator as well as a controller, the device containing at least two processors, wherein at least one program memory which contains program code is assigned to each of the at least two processors, and the program code in the at least two program memories is identical.

2. The device according to Claim 1, wherein the at least one sensor is connected to a first processor, and the at least one actuator is connected to the first processor or to at least one second processor, the processors also being connected.

3. The device according to Claim 1, wherein at least two sensors and at least two actuators are provided, and each sensor and each actuator is assigned to one processor and the program memory assigned to it.

4. A control unit for controlling a drive unit, in particular of an internal combustion engine in a vehicle, which contains two processors, wherein at least one program memory which contains program code is assigned to each of the at least two processors, and the program code in the at least two program memories is identical.

5. A method of controlling a drive unit, in particular of an internal combustion engine in a vehicle, at least one performance quantity of the drive unit being determined, and as a function of the performance quantity, at least one actuator of the drive unit being controlled according to predefinable or selectable functionalities using controlled variables; in at least one controller, at least two processors processing the possible functionalities, and the functionalities being predefined by program code in at least one program memory assigned to each processor, wherein the

possible functionalities per processor and the program codes in the program memories assigned to the processors are identical.

6. The method according to Claim 5, wherein the at least one performance quantity is processed in a first processor, and the at least one actuator is controlled with at least one controlled variable from the first processor or from at least one second processor, the processors exchanging information.

7. The method according to Claim 5, wherein a distinction is made between performance quantities of the first type and of the second type, the performance quantities of the first type being processed in the functionalities of both processors, and the performance quantities of the second type being processed only in the functionalities of one processor.

8. The method according to Claim 5 or 7, wherein a distinction is made between controlled variables of the first type and controlled variables of the second type, the controlled variables of the first type being formed by the functionalities of a first processor from the performance quantities which are processed in the functionalities of a first processor, and the controlled variables of the second type being formed by the functionalities of the first processor from the performance quantities which are processed in the functionalities of a second processor, and the functionalities of the at least two processors exchanging information.

Abstract

A method and a device for controlling a drive unit, in particular of an internal combustion engine in a vehicle are described, and at least one performance quantity of the drive unit is detected and at least one actuator of the drive unit is controlled with controlled variables, depending on this performance quantity, according to predefinable or preselectable functionalities. In a controller, at least two processors process the possible functionalities, where these functionalities are defined by program code in at least one assigned program memory per processor. These possible functionalities of the processors, i.e., the program codes in the program memories assigned to the processors are identical.

(Figure 3)

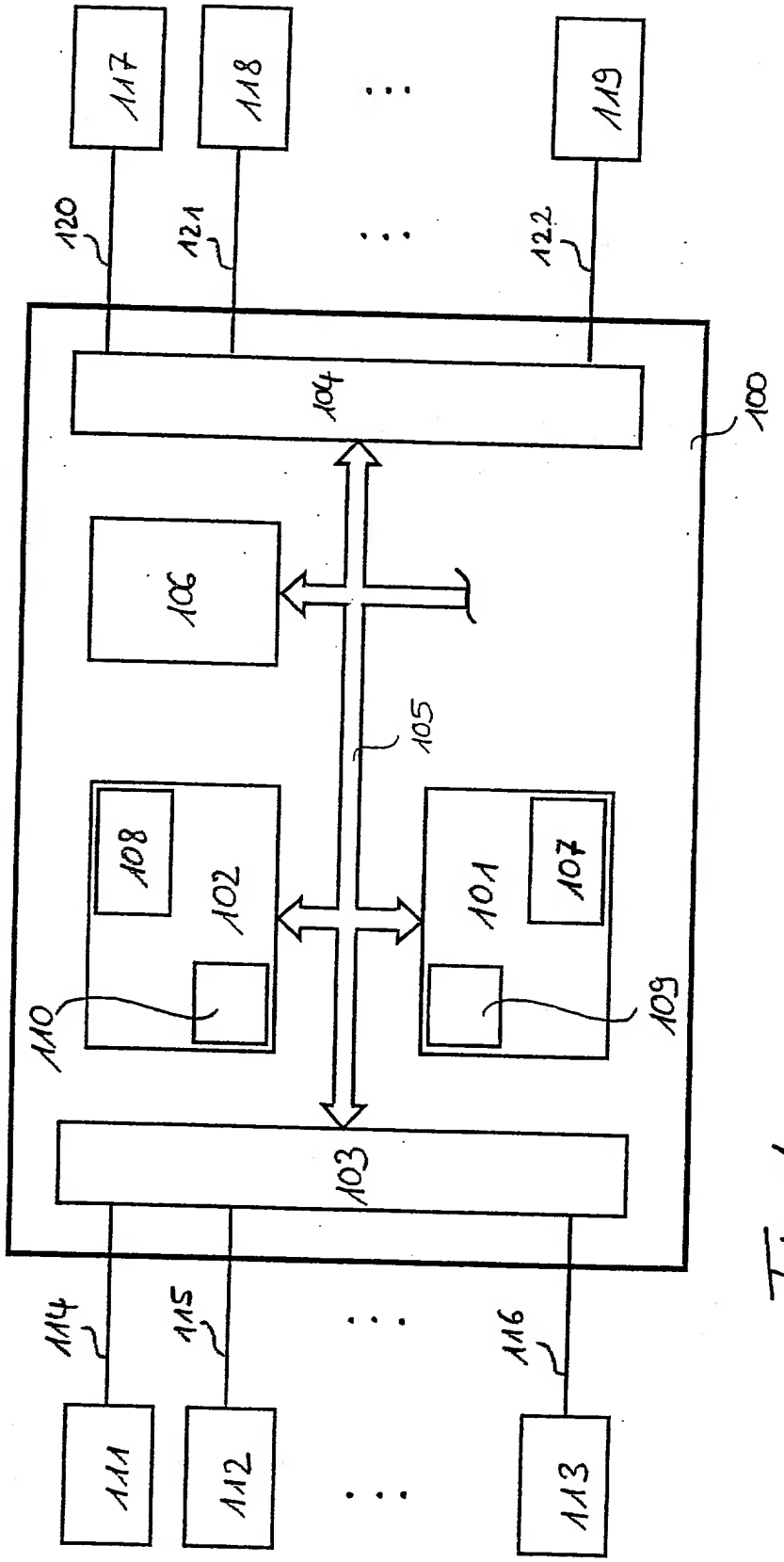

Fig. 1

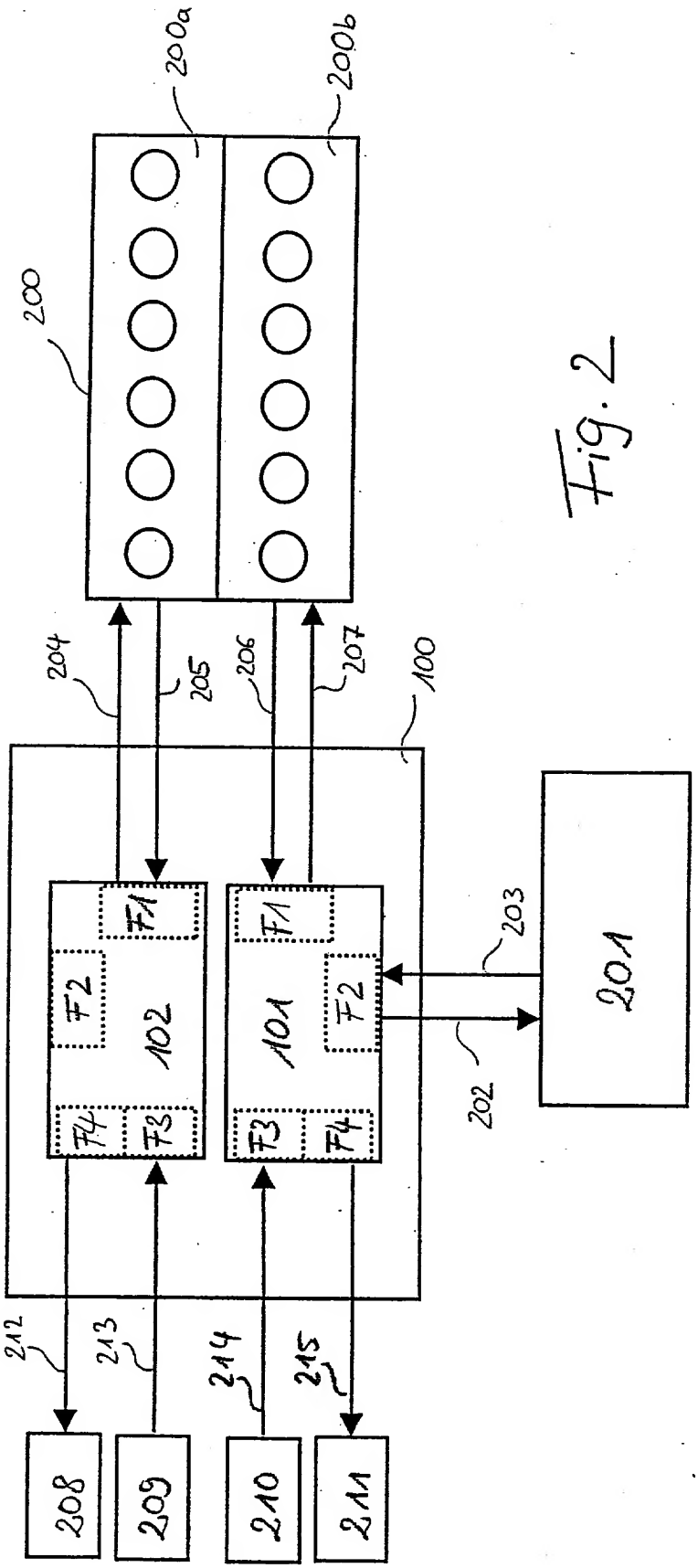

Fig. 2

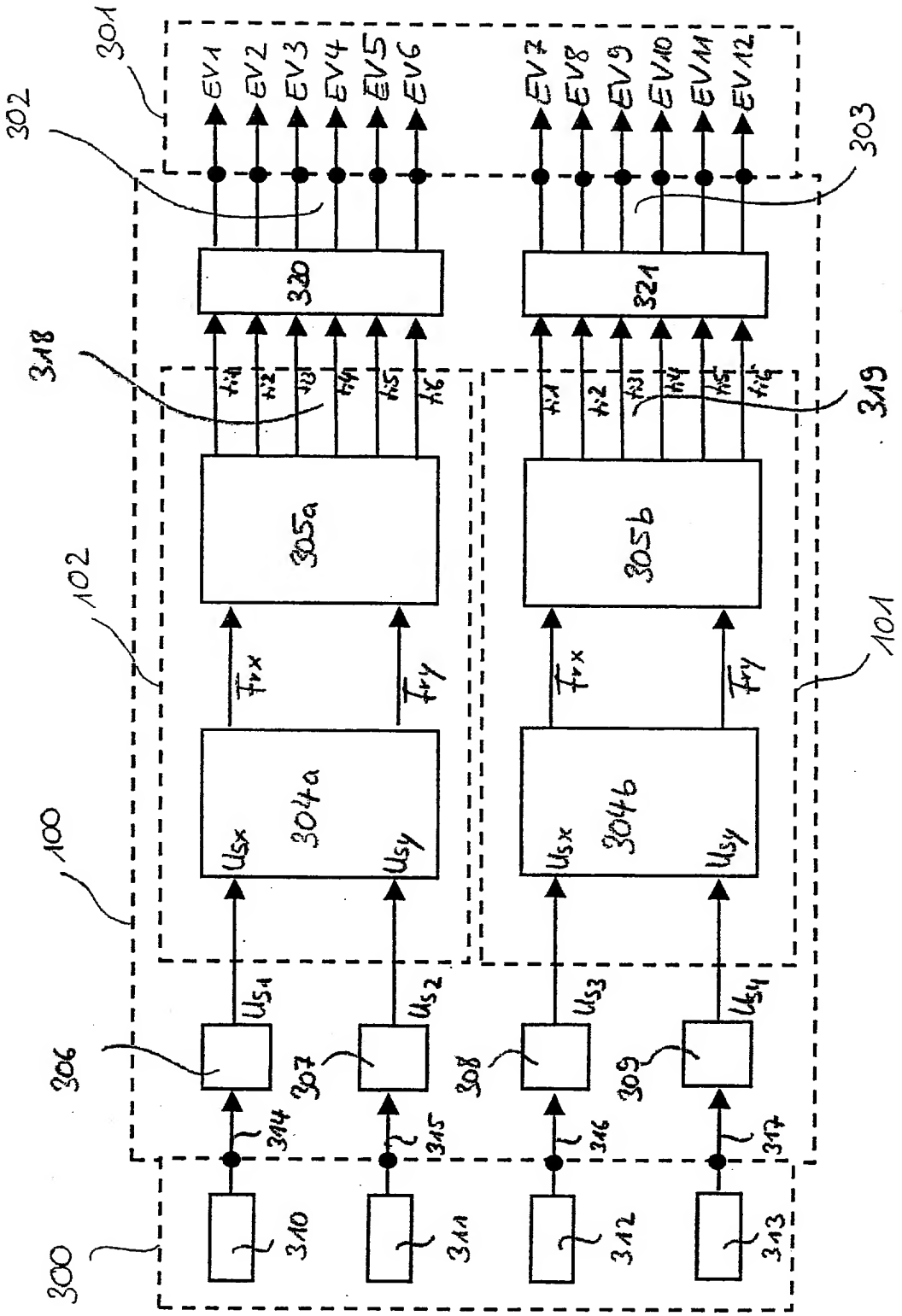

Fig. 3

DEVICE AND METHOD OF CONTROLLING A DRIVE UNIT

FIELD OF THE INVENTION

The present invention relates to a device and a method of controlling a drive unit, in particular, an internal combustion engine in a vehicle.

BACKGROUND INFORMATION

German Published Patent Application No. 42 31 449 discusses a device for controlling the drive power of an engine having at least two control units, a first control unit being connected to a first group of measuring devices and a second control unit being connected to a second group of measuring devices of the same measuring element. There may be special advantages of an engine which has two independent cylinder blocks and is controlled by two control units or controllers. Due to the fact that multiple control units are connected to only one measuring element for detection of the performance quantity, a high availability and operating reliability may be guaranteed. The system presented here having two control units has an asymmetrical functionality and program code and originally has a main computer, which is heavily utilized, and an emergency computer, which is only lightly utilized. Individual functions of the main computer are shifted to the emergency computer to optimize computation time and memory.

Instead of two controllers, German Published Patent Application No. 35 39 407 discusses a computer system having two processors for regulating characteristic quantities of an internal combustion engine. The two processors share the computer load in normal operation, each of the two processors being able to maintain emergency operation as an emergency

computer in the event of malfunction. Thus, only the functions needed in emergency operation are implemented on both processors. However, in emergency operation these functions have a reduced extent of performance and function in comparison with normal operation. Due to this increased redundancy and division of work in normal computer operation, which is possible as part of the emergency function, reliability and operating speed may be increased.

Due to the asymmetrical division of functions of each controller or processor, the respective functionality must be defined, implemented, documented, tested, and maintained separately. Likewise, both controllers or computers must be equipped in the development stage with expensive measuring arrangements and/or emulation arrangements. Due to the asymmetrical definition of the functionality and therefore the asymmetrical definition of the systems, additional errors may occur due to a mix-up during assembly of the components, for example. At the same time, a further development of or change in functionality in the existing system requires that both controllers or computers and their respective functionalities be taken into account, which consequently is very complicated, time consuming and cost intensive.

This results in the object of implementing an engine control system having a very high functionality which is optimized with respect to other prior systems.

SUMMARY OF THE INVENTION

A control system of a drive unit, in particular, of an internal combustion engine including a control unit where the control unit contains at least two computers, is described. The functionality of the control unit or controller, too complex for one computer, may be divided among at least two computers in one controller. The program memories of the two computers or computing units contain the same program code, so that both computers may have an identical possible

functionality. Thus the individual functionalities may be selectable to be less complex than the required overall functionality, so that the complex overall functionality may nevertheless be obtained via all computers or processors. In use, largely the same program code may be run through, although there may be individual parts that are present in both memories or computers but are processed asymmetrically, i.e., only in or from one memory.

The functions may be divided among more than two computers, or additional computers may be present in the overall system, although they execute a different program code, i.e., they have a different functionality. The computers may then be appropriately accommodated in different controllers.

The two computers having identical possible functionalities may appropriately exchange information, e.g., over a serial or parallel bus system such as a CAN bus or other serial interfaces or a DPRAM. It may be advantageous that the functionality need only be defined, implemented, documented, tested and maintained once due to the symmetrical division of function and the identical functionalities, but it may be used for both computers or computer units.

In manufacturing the controller, e.g., in prototype building or in production, the program memory which contains the program code and thus the functionality may be assembled twice in the controller, so there may be no possibility of mix-ups.

In the development and application phase, one may appropriately concentrate on one of the symmetrical sides. It may be sufficient to equip one side with expensive measuring arrangements or emulation devices. Due to the symmetrical division of functions and the symmetrical functionality on both computers, a modular design of the controller and the controller program may be possible. This makes further developments through changes in existing functions and/or

introduction of new functions much easier and faster in comparison with an asymmetrical structure because there may be no interface problems or timing problems between the functions distributed among the computers. This results in lower development costs and shorter development times.

The main point is thus the symmetry and functionality of the computer system and the use of program memories including a completely identical program code for the at least two computers or computing units in the controller.

The present invention is described in greater detail below on the basis of the exemplary embodiments illustrated in the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows a block diagram of a control unit including two computing elements or computers which control at least one performance quantity in the vehicle, for example the performance of a drive unit, in particular, of an internal combustion engine.

Figure 2 illustrates functional relationships between the two computers in the controller and their environment.

Figure 3 shows the exemplary embodiment with functional relationships based on lambda regulation for calculation of injection in the internal combustion engine.

DETAILED DESCRIPTION

Figure 1 shows an electronic controller 100, which includes at least two computers 101 and 102, an input module 103, an output module 104 and a bus system 105. Other components and/or modules may optionally be connected to bus system 105 as indicated by element 106. These additional optional elements include, for example, additional memory elements and/or an additional bus input/output interface, e.g., for

diagnosis or for connection of controller 100 to other controllers. Input module 103 may be combined with output module 104 as well as the input/output module. Computer 101 contains, among other things, a processor 109 and a program memory 107 assigned to this processor 109. The program code filed in program memory 107 corresponds to the possible functionality with regard to the control or regulation of at least one performance quantity such as that it may be processable by processor 109. It may be advantageous for the reasons given above if first computer 101 and second computer 102 have a completely identical design, likewise with a processor 110 and a program memory 108 allocated to them. However, different computers may optionally also be used as long as the possible functionality of both computing units is identical. Input module 103 receives signals which represent measured performance quantities of the drive unit, the drive train and/or the vehicle or from which such performance quantities may be derived. These may be performance quantities which may be analyzed to control an internal combustion engine. These signals may be picked up by measuring devices 111 through 113, in particular, sensors, and may be sent to input module 103 via input lines 114 through 116.

Furthermore, signals which actuate control elements or actuators for setting at least one performance quantity of the drive unit, in particular, the internal combustion engine of the vehicle, may be output via output module 104. The corresponding signals for controlling actuators 117 through 119 may be delivered via output lines 120 through 122. Depending on the input signals, performance quantities and/or internal quantities derived from them, computers 101 and 102 form values for the controlled variables which may be output and which set the control elements in the sense of a predetermined control or regulatory strategy as part of the programs implemented therein. Controller 100 may be a control unit for controlling a drive unit, in particular, of an internal combustion engine, of a vehicle, so the position of

an operating element that may be operated by the driver may be detected and analyzed in a known way and a setpoint value for a torque of the drive unit may be determined. A setpoint value for the torque may then be determined by taking into account setpoint values of other control systems received over input module 103, e.g., a traction control, a transmission control, etc., as well as setpoint values formed internally (limits, etc.). Then in an exemplary embodiment of an internal combustion engine control system, this may be converted to a setpoint value for setting the throttle valve, which may be set as part of a position control loop. Furthermore, depending on the design of the internal combustion engine, additional performance-determining functions may be provided, e.g., a control for a turbo charger of an exhaust gas recycling system, an idling speed regulation, etc.

In addition, with internal combustion engines having direct gasoline injection, not only the air setting but also the determination of the fuel mass to be injected, the determination of an air/fuel ratio to be set, the preselection of the injection course (pre-injection, post-injection), the control of a charge movement valve, etc., have a crucial effect on performance, so that, in addition to the programs described there, a plurality of other programs may be provided which have an influence on the performance of the internal combustion engine and thus on the safety of the vehicle.

This plurality of programs may be filed or may be installed in the form of a program code in respective program memories 107 and 108 of the computer. The functionalities of a controller represented by the programs or program code in the program memory as described here may be very complex. Therefore, these complex functionalities of the controller should be divided symmetrically between at least two computers in such a controller. The computers may exchange information, e.g., over a communication system, in particular a bus system such as a CAN bus or another serial or parallel interface or a memory

element, in particular, a DPRAM. Program memories 107 and 108 of two computers 101 and 102 contain the same program code. In addition, the identical program code may be executed to a great extent, but there may be individual parts which, for some reason, are processed asymmetrically. For example, the required programs or sections to be processed asymmetrically may then be activated or deactivated via hardware lines and signals transmitted on them. For the sake of simplicity of the diagram, these line connections may be represented by communication system 105 and/or may be integrated into it.

The procedure described above is illustrated in Figure 2 with regard to a division of functions F1 through F4 as an example. The controller is again labeled as 100, and the two computers are labeled as 101 and 102. An internal combustion engine including the respective actuators and sensors is labeled as 200. This specific example shows an internal combustion engine including 12 cylinders divided into two cylinder blocks of six cylinders each. The 12 cylinders are only an example, and it may be equally possible for a different number of cylinders to be provided in respective cylinder blocks 200a and 200b, each including the respective sensors and other actuators. Thus, in a 12-cylinder engine, for example, six cylinders may be operated by each computer with regard to ignition and injection in a gasoline engine. The functionality may be distributed symmetrically among the two computers. Functionality F1 controls one cylinder block with the respective sensors and actuators of the internal combustion engine. Sensor quantities such as the air/fuel ratio, the camshaft or crankshaft position, knocking information, air mass, etc. from internal combustion engine 200 may be sent to computers 101 and 102, in particular, their functionality F1 (205, 206). Actuating signals (204, 207) from functionality F1 reach the internal combustion engine or its actuators. Oriented connections 204 through 207 represent the functionality of the transmission per se.

Circuit parts or sensors may be used via both processors. For example, the sensor, e.g., a hot film air mass flow sensor and an input circuit, e.g., a low-pass filter, may be present only once for cost reasons, but the sensor signal, e.g., an A/D-converted air flow, may be available to the functionalities in both computers.

Likewise, a controller, e.g., a secondary air pump including the corresponding output stage in the controller may be operated by only one computer, whereas the respective engine function, e.g., the secondary air control including diagnosis, runs symmetrically in both computers and also supplies quantities for other engine functions.

In addition, actuators such as secondary air valve for a first cylinder block may be operated by the computer for the other cylinder block, namely the second, although the respective engine function may be running in the computer for the first cylinder block.

The program code for operation of the actuator, e.g., for regulating the position of the throttle valve, may run symmetrically in both computers, in which case, however, the output stage and the actuator may be operated on one cylinder block, but on the other cylinder block the signal from the computer may be not used for control purposes.

Due to the exemplary embodiments described above as well as the following description of the tank system, despite the identity of the functionalities and the program code, certain asymmetries may be provided.

Additional peripherals such as a tank system 201 may be controlled and monitored by another functionality F2. This functionality F2 may be likewise contained symmetrically in both computers 101 and 102. However, it may be processed only asymmetrically by computer 101, for example. Therefore, this

functionality F2 may be activated or deactivated by signals of separate hardware lines or by unambiguous signals or data over the communication system. Thus, if there is only one tank in the vehicle, diagnosis of the tank is performed in only one computer. Although corresponding functionality F2 is present on both computers in the program memory, it is activated on only one side. The communication relationship between functionality F2 in computer 101 and tank system 201 may be represented by connections 202 and 203.

In addition, functionalities F3 and F4 may also be provided for other peripheral elements, so that, on one hand, sensor elements 209 and 210 may be input and processed via communication link 213 and 214 (F3). On the other hand, control elements, actuators 208 and 211 may also be operated via communication links 212 and 215 by functionalities F4. Likewise, quantities to or from other control systems such as a traction control, a transmission control, etc. may be relayed via oriented connections 212 through 215. If sensor element 209 and control element 208 are elements of the same control loop, functionalities F3 and F4 may also be considered together as functionality F34.

Figure 3 shows an exemplary embodiment of a 12-cylinder engine having a concrete functionality. Thus, this 12-cylinder engine may have four parallel exhaust gas lines, for example, including four regulating probes 310 through 313, combined as lambda probes 300. Thus a quadro lambda regulation would have to be provided in the engine control unit, but because of its high complexity this entails not only increased costs but also risks with regard to malfunctions, in particular, security risks. Due to the symmetrical division of functions between two computers, there may be only one stereo-lambda regulation in each computer 101 or 102 in controller 100, i.e., the functionality may be far less complex. The signals supplied by probes 310 through 313 go via interfaces 314 through 317 for hardware processing. This signal processing takes place

through elements 308 and 309 for computer 101 and through elements 306 and 307 for computer 102. Probe signals US1 and US2 may be sent to computer 102, and probe signals US3 and US4 may be sent to computer 101.

Thus only two probe signals may be analyzed in each computer, and the lambda regulation factors act, as explained later, only on six injectors via the injection calculation. Then, as stated previously, the same-stereo lambda regulation may be performed in block 304a and 304b. To do so, processed probe signals US1 and US2 enter the regulation as probe signals USX and USY. Likewise, processed probe signals US3 and US4 in block 304b also enter as USX and USY into the same stereo-lambda regulation. Regulating factors FRX and FRY that are obtained from the stereo-lambda regulation may be relayed to downstream blocks 305a and 305b for computer 102 and computer 101, respectively.

Based on regulation factors FRX and FRY, the same injection calculation may then be performed in blocks 305a and 305b for six injectors in this exemplary embodiment. The resulting output quantity groups 318 and 319 may then be relayed to output stage blocks 320 and 321.

On the basis of the same program code or the identical functionalities, the function blocks are also identical. Likewise, input quantities, output quantities and state variables of computers 101 and 102 have identical designations. Output quantities 318 and 319 are equally designated as ti1 through ti6, although they have physically different meanings. Thus, ti1 may be used once for controlling injector 1, EV1, and once for controlling injector 7, EV7. However, this has no relevance for the function or functionality or the program code. Injectors 301 may then be controlled via interface 302 or 303 from output stage blocks 320 and 321.

The symmetrical distribution of functions discussed above is illustrated in Figures 1, 2 and 3, although parts may be processed asymmetrically. Nevertheless, the functionality and the program code are identical for both computers and are run through in both computers independently of one another. There is no redundancy and there are no emergency operating properties in sensors, output stages or functionality. Such a redundancy would have to be generated additionally, independently of the exemplary embodiments according to the present invention.

ABSTRACT OF THE DISCLOSURE

A method and a device for controlling a drive unit, in particular, of an internal combustion engine in a vehicle, in which at least one performance quantity of the drive unit is detected and at least one actuator of the drive unit is controlled with controlled variables, depending on this performance quantity, according to predefinable or preselectable functionalities. In a controller, at least two processors process the possible functionalities, where these functionalities are defined by program code in at least one assigned program memory per processor. These possible functionalities of the processors, i.e., the program codes in the program memories assigned to the processors are identical.

R. 36016

[10191/2329]

DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled **DEVICE AND METHOD OF CONTROLLING A DRIVE UNIT**, the specification of which was filed as International Application **PCT/DE00/02546** on August 2, 2000;

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, § 1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application(s) for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S)

Number	Country filed	Day/month/year	Priority Claimed Under 35 USC 119
199 47 252.1	Fed. Rep. of Germany	30 Sept. 1999	Yes

EL 234417723

And I hereby appoint Richard L. Mayer (Reg. No. 22,490) and Gerard A. Messina (Reg. No. 35,952) my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful and false statements may jeopardize the validity of the application or any patent issued thereon.

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